09 MAR 2005

10/[illegible]

P[illegible]AU03/01156

#2

REC'D 24 SEP 2003

WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Patent Office
Canberra

I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003904065 for a patent by VAPORATE PTY LTD as filed on 01 August 2003.

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Twelfth day of September 2003

J R Yabsley

JONNE YABSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

BEST AVAILABLE COPY

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

VAPORATE PTY LTD

Invention Title:

FUEL DELIVERY SYSTEM AND INJECTOR

The invention is described in the following statement:

FUEL DELIVERY SYSTEM AND INJECTOR

FIELD OF THE INVENTION

This invention relates to a fuel delivery system and, in particular, to systems for diesel and petrol or gasoline engines, and also to an injector for use in the system.

BACKGROUND OF THE INVENTION

Our International Application No. PCT/AU02/00403 discloses a fuel delivery system in which fuel is injected into an air intake system in order for the fuel to be delivered to a combustion chamber of the engine. The contents of this International application are incorporated into this specification by this reference.

The International application discloses heating of the fuel in the end region of the injector so that when the fuel leaves the end region, it immediately converts to vapor state, because of the heating of the fuel and the change in pressure experienced by the fuel when the fuel leaves the injector and enters the chamber of the engine. The International application discloses several methods of heating the end region including exhaust gas and direct conducted heat from the engine.

Whilst the systems of the International application do operate extremely well, they do suffer from the drawback of requiring the engine to heat up before the systems become fully effective.

SUMMARY OF THE INVENTION

The object of the invention is to provide a fuel delivery system and injector which overcomes the above drawback.

The invention may be said to reside in a fuel delivery system for an engine which has a combustion chamber, a

piston movable in the combustion chamber, an air inlet port and an exhaust port, comprising:

an injector port in the engine having a first open end communicating with the combustion chamber, and a second end remote from the first end, the injector port having an injector port wall;

a fuel injector located in the injector port, the fuel injector having an injector main body which houses electrical components for operating of the injector, an injection tip and an end region adjacent the tip, the end region being for storing fuel to be ejected from the injector;

an electrical heating element surrounding the end region exterior of the fuel injector; and

an electric current supply for supplying current to the heating element for heating the end region of the injector to in turn heat the fuel in the end region so that when the fuel leaves the injector, the fuel substantially immediately converts to vapor because of the heating of the fuel and the change in pressure experienced by the fuel when the fuel leaves the injector.

Thus, because the heating of the injector is performed by electric current, it is not necessary for the engine to reach operating temperature before the system will operate adequately. Thus, the heating element can be activated immediately the engine is turned on so that the injector end region is heated substantially immediately and the system operates to heat the fuel much quicker than is the case if engine temperature or exhaust gas temperature is used to heat the end region.

Preferably, the heating element is provided in a cylindrical sleeve which locates over the end region of the injector, and sits between the end region of the injector and the injector port wall of the injector port in the engine.

Preferably, the current supply comprises at least one conductor extending from the heating element to a current supply device.

Preferably, the current supply device comprises a battery for supplying current and a pulse width modulator for modulating the current supplied by the battery so that the current supplied to the heating element is pulsed width modulated so that the amount of current supplied to the heating element can be controlled to thereby control the heating of the heating element, and therefore the heating of the fuel within the injector end region.

Preferably, the current supply includes a relay so that current is supplied when the relay is closed, and a control current supply for closing the relay.

Preferably, the control current supply comprises a signal from a fuel pump relay which passes through an engine temperature sensor so that if the engine temperature is below a predetermined temperature, the relay is closed to thereby enable current to be supplied to the heating element.

Preferably the fuel injector includes a temperature sensor for monitoring the temperature of the fuel in the end region and for opening the relay when the temperature reaches a predetermined temperature.

The invention also provides an injector for injecting fuel into an engine, comprising:

an injector body having a tip, an end region adjacent the tip for storing fuel, and a main body portion in which electrical components for operating the injector are housed;

the end region having an outer surface formed from heat conducting material; and

a heater sleeve arranged on the end region and surrounding the end region, the sleeve including a heater element for receiving electric current to heat the heater element, and therefore conduct heat through the heat conducting outer surface of the end region into the end region of the injector for heating fuel in the end region of the injector so that when the fuel is ejected from the end region the fuel substantially immediately converts to vapor state because of the heating of the fuel and the change in pressure experienced by the fuel when the fuel leaves the injector.

Preferably, the sleeve is formed from a high temperature silicon in which the heating element is embedded by molding.

Preferably, the heating element comprises a coiled wire. However, in other embodiments, the heating element may be in the form of a semi-cylindrical plate.

Preferably the coiled wire includes a sheath which surrounds the coiled wire to maintain turns of the coiled wire separated from one another when the coiled wire is molded in the sleeve.

Preferably a temperature sensor is disposed adjacent the end region of the injector for monitoring the temperature of the end region of the injector, and therefore the fuel in the end region of the injector.

Preferably the heater sleeve includes a central opening having a peripheral wall for receiving the end region of the injector, and the temperature sensor is arranged between the end region of the injector and the peripheral wall.

The invention may also be said to reside in a fuel delivery system for an engine which has a combustion chamber, a piston moveable in the combustion chamber, an air inlet port, an air inlet port and an exhaust port, comprising:

an injector port in the engine having a first open end communicating with the combustion chamber, and a second end remote from the first end, the injector port having an injector port wall;

a fuel injector located in the injector port, the fuel injector having an injector main body which houses electrical components for operating the injector, an injector tip and an end region adjacent the tip, the end region being for storing fuel to be ejected from the injector;

an electrical heating element for heating the fuel in the end region of the injector;

an electrical current supply for supplying current to the heating element for heating the end region of the injector;

a heat conducting path from the engine to the end region of the injector so the end region of the injector can be heated by heat conducted from the engine;

a current shut-off for shutting off supply of current to the electrical heating element; and

whereupon initial startup of the engine, current is supplied to the electrical heating element to heat the fuel in the end region of the engine, and after initial heating of the fuel in the end region, the current shut-off shuts off current to the engine so the end region is continued to be heated by direct conduction of heat from the engine through the direct conduction path.

Preferably the injector port is located in a manifold connected to the air inlet port and the direct conduction path includes a heat conducting gasket between the inlet

port and the manifold for conducting heat to the manifold and then to the end region of the injector.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a view of a fuel delivery system according to the preferred embodiment of the invention installed in an engine;

Figure 2 is a side view of part of the system of Figure 1;

Figure 3 is an end view of the part shown in Figure 2;

Figure 4 is a view similar to Figure 2 but showing part of the internal structure of the component of Figure 2;

Figure 5 is an enlarged view of the circled part of Figure 4;

Figure 6 is a view similar to Figure 4 of a further embodiment;

Figure 7 is a cross-sectional view of the embodiment of Figure 6;

Figure 8 is a view of a still further embodiment of the invention;

Figure 9 is an enlarged view of the circled part of Figure 8;

Figure 10 is a cross-section view along the line X-X of Figure 9; and

Figure 11 is a circuit diagram according to the preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figure 1, an engine 10 is shown which has a cylinder 12 in which a piston 14 is mounted. The engine 10 has an inlet port 16 and an exhaust port 18. An inlet manifold 20 is connected to the inlet port 16.

An injector port 22 is arranged in the inlet member for receiving a fuel injector 24 so fuel can be injected into the inlet port 16 and conveyed to the cylinder 12 with inlet air.

The injector 24 is a standard fuel injector which has a tip 26, a main body portion 28 and end region 30 adjacent the tip 26. The main body 28 contains the electrical componentry for operating the injector in accordance with control from the engine ECU (not shown). The end region 30 stores fuel to be ejected from the injector. The injector 24 is modified only by removing the outer casing around the end region 30 so as to leave the metal peripheral wall of the end region 30 exposed. A heater sleeve 32 is provided on the end region 30 and is dimensioned so that the sleeve 32 together with the injector 24 fits into the existing injector port 22 without any modification. The sleeve 32 also performs a function of a seal to seal the injector 24 in the port 22.

The sleeve 32 carries an electric heating element 38, and current is supplied to the element 38 by conductors 40. The conductors 40 are connected to a connector 42 which in turn connects to an electrical system (not shown in Figure 1) for supplying electric power to the heating element 38 so the heating element is heated to in turn heat the end region 30 of the injector 24 and the fuel which is contained in the end region, but does not heat the main body portion 28 in which the electrical componentry is contained. Thus, as in the earlier International application previously mentioned, the end region of the injector 30 is heated to in turn heat the fuel in the end region so that when the fuel is ejected from the tip 26, the fuel substantially immediately converts to vapor because of the heating of the fuel and the change in

pressure experienced by the fuel when the fuel leaves the injector and enters the port 22 and inlet port 16.

Figures 2 and 3 are a more detailed view of the sleeve 24. As is apparent from Figures 2 and 3, the sleeve 24 is a generally cylindrical body having a central opening 41 in which end region 30 is received, a tapered front 43 and a rear flange 42. The heating element 38 may comprise a coil of wire which is molded and embedded in the sleeve 32 and conductors 40 are a continuation of the coil within the sleeve 32 and joined to connector 42 as previously mentioned.

Figure 4 is a view which shows the coil 38 in more detail, as does the enlarged view of Figure 5. As is apparent from Figures 4 and 5, the coil which forms the heating element 38 comprises a number of turns 38a which are spaced apart from one another so the turns do not touch and join with the conductors 40 so current can be supplied to the heating coil 38 to heat the heating coil. Figures 4 and 5 also show the central cavity or bore 41 in which the end region 30 of the injector 24 locates.

In the preferred embodiment of the invention, the heating element 38 is formed from nicane wire which offers a resistance to the current supplied by the conductors 40, thereby heating up the heating coil 38 as current travels through the coil 38. The heater sleeve 32 is preferably formed from a high temperature silicon which is heat conducting so that heat generated by the coil 38 is conducted through the sleeve 32 to the end region 30 of the injector 24. In other embodiments, the sleeve 32 could be formed from other materials such as high temperature plastics, ceramics, and the like.

Figures 6 and 7 show a second embodiment of the invention, in which the turns 38a are contained within a sheath 44.

The sheath 44 prevents the wire turns 38a from coming into contact with one another, should the turns 38a be pushed slightly during the molding of the sleeve 32, and therefore prevents short circuiting within the coil 38 which would impair the operation and heat efficiency of the heating sleeve 32. The sheath 44 therefore makes molding easier because it is not necessary to ensure that the turns 38a remain apart from one another, and therefore may avoid the need for an inner mandrill or sleeve on which the turns 38a are mounted when the coil 38 is located in a mold for molding of the sleeve 32.

Figures 8 and 9 show a further embodiment of the invention in which the heating element 38 is in the form of a C-shaped band, as best seen in the cross-sectional view of Figure 10. Thus, the preferred embodiment of the invention enables a conventional injector to be used save for the need to remove the outer casing surrounding the end region 30, and also avoids the need to use separate seals to seal the injector in the injector port 22. The sleeve 32 performs the function of locating the injector 24 in the port 22 and also sealing the injector in the port, as well as heating the end region 30, as described above.

Figure 11 is a block circuit diagram showing operation of the preferred embodiment of the invention. The circuit includes a battery 50 and alternator 52 which supply current to a relay 54. The battery also supplies power to a fuel pump relay 54 and then to a fuel pump 56, as is conventional. The relay 54 is tapped into the circuit between the fuel pump relay 54 and fuel pump 56 by line 57, as shown in Figure 11. Thus, when the vehicle engine is initially turned over by starting the engine, the fuel pump relay is closed so that power is supplied to the fuel pump. Immediately on starting of the engine, power is therefore supplied on line 57. The line 57 includes an

engine temperature sensor 58 which monitors the temperature of the engine, and if the temperature is below a predetermined temperature, the engine temperature sensor supplies the current on line 57 to the relay 54, which causes the relay 54 to close.

When the relay 54 is closed, current is supplied from the alternator 52 to the heating element 38 of the injector 24.

Figure 10 shows six injectors 24, each with their own heating 38 arranged in series. However, it should be understood that different configurations could be used, such as some of the injectors 24 could be wired in series, and some parallel or all could be wired in parallel, depending on the application, the number of cylinders, and therefore the number of injectors required, and the voltage capacity of the barratry which powers the vehicle.

In the preferred embodiment of the invention, a pulse width modulator 60 is also located in the line 61 between the relay 54 and the injectors 24 so that a pulse width signal is supplied to the elements 38. The pulse width modulator 60 may be controlled to alter the pulse width or duty cycle of the signal supplied to the elements 38 to control the degree of heating of the elements 38 in accordance with the requirements of the engine during operation. Thus, the pulse width modulator 60 can be used to maintain a constant temperature output by the heating elements 38 with reduced power requirements. The pulse width modulator 60 will also draw approximately half the power requirements than embodiments without the pulse width modulator because of the modulation of the signals supplied to the heating elements 38.

The pulse width modulator 60 also enables a smaller heating element to be used in the sleeve 32. The reason

for this is that if the heating element 38 is continuously heated by usual battery supply power, the heating element can easily overheat. Thus, in order to ensure this does not happen, the heating element needs to be relatively large diameter and also relatively long. This creates problems because of the relatively small size of the sleeve 38. By using the pulse width modulator which reduces the amount of current which is supplied to the heating element, the length of the heating element 38 and the wire diameter or wire gauge can be made smaller.

When the engine temperature reaches a predetermined temperature, the sensor 58 can shut off power supply to the relay 54, thereby causing the relay 54 to open and shut off current to the heating elements 38.

In another embodiment of the invention, rather than rely on the engine temperature sensor 58 to switch the relay on and off, a further temperature sensor switch 90 can be incorporated in the line 57. This switch may be used in combination with the engine temperature sensor 58, or instead of the engine temperature sensor 58. The switch 90 is connected to a heat sensing probe 92 which is located in the sleeve 32 between the end region 30 of the injector 24 and the peripheral wall of the central opening 41 of the sleeve 32. The sensor 92 may be in the form of a thermo-couple and connected to the switch by lines 94. Thus, the temperature sensor 92 more accurately detects the actual fuel temperature within the end region 30 so that when the temperature does reach the required level, the switch 90 can be opened so that power is disconnected to the relay 54, thereby causing the relay 54 to open so power is not supplied from the battery 50 to the heating elements 38. If the temperature of the fuel decreases below a predetermined value, the switch 90 can be closed so the heating element 38 is again energised to heat the end region 30 of the injector.

Preferably the temperature of the fuel in the end region 30 is in the range of about 80 to 92°C, and therefore the use of the temperature sensor 92 in close proximity to the end region 30 provides a better measure of the temperature of the fuel, and therefore a better indication of when the electrical heating element 38 can be switched off.

The sleeves 32, as is previously described, are heat conductive so that heat is conducted from the hot engine through the sleeve 32 and to the end region 30 of the injector 40, so the end region is heated by direct heat from the engine rather than heat from the heating element 38. Thus, the end region can be heated in the manner which is described in our co-pending Provisional Application Number 2002951332, the contents of which are incorporated into this specification by this reference. Thus, the manifold 20 may be connected to cylinder block 19 of the engine 10 by a heat conducting gasket (not shown) so that heat is conducted from the cylinder block 19 to the inlet manifold 20 surrounding the port 22 so heat is in turn conducted through to the end region 30 in the same manner as disclosed in the above-mentioned provisional application.

Thus, when the temperature sensor 92 indicates that the heating element 38 has heated the fuel in the end region 30 to the required temperature, the heating element 38 can be switched off by the switch 90 and maintenance of the required heat is maintained by conduction from the engine to the sleeve 32, and then to the end region 30. If for any reason the temperature of the fuel does drop below the predetermined level, the switch 90 can close to supply power to the relay 54 to again energise the heating element 38.

As shown in Figure 11, only one of the injectors 24 is shown with the temperature sensor 92. However, all of the injectors 24 can be provided with the temperature sensor 92 and connected to the switch 90, and the relay and pulse width modulator could be arranged so that independent power supplies can be supplied to each of the heating elements 38 so that each injector is separately monitored for temperature of the fuel in the end region, and separately heated by its respective heating element 38 when needed.

Thus, the preferred embodiment of the invention has the advantage that heat is instantly applied to the end region 30 of the injector as soon as the engine is started. Tests have shown that the end region 30 can be heated in approximately 20-40 seconds or less to bring the fuel in the end region 30 up to the required temperature, whereas if engine temperature is required, it may take approximately 5 to 15 minutes for the engine to heat sufficiently so that the fuel in the end region 30 is brought to the required temperature.

The circuitry shown in Figure 11 may be formed as part of the engine operating loom, or if the system is added to an existing vehicle, may be provided in its own loom or as a separate wiring system.

Whilst the temperature sensor 58 can switch off the relay 54 when the operating temperature of the engine reaches a predetermined temperature, the sensor 58 could be controlled to power the relay 54 or the relay 54 could otherwise be powered to close the relay in other operating conditions, such as when higher engine loads exist and more fuel is required, so that the additional fuel is adequately and quickly heated by the heating element 38, as well as conducted heat from the engine 10.

Thus, the preferred embodiment of the invention can be provided as a retrofit system for existing engines, or it could be provided as original equipment. If provided as an original equipment, the control of the heating element 38 can be performed in accordance with the above description by the engine electronic control unit (not shown) of the vehicle. Thus, the injectors 24 will be coupled to the ECU as is usual, and the ECU could be programmed so as to monitor the temperature signal from the sensors 92 and switch the power to the heating elements 38 when needed (ie. at startup of the engine) and if the fuel temperature in the end region 30 drops during normal operation. Thus, the injector would be provided with the sleeve 32 as original equipment and the electrical supply to the injector would be the normal pulse supply from the ECU to control the fuel ejection from the injector, the heating conductors 40 for the supply of electricity to the heating element 38, and the lines 94 for the temperature measurement from the sensor 92.

The sensor 92 may be sandwiched tightly between the end region 30 and the inner wall of the central opening 41, or may be provided just in the inner wall 41 in a groove or recess of the inner wall so the temperature sensor 92 still abuts the end region 30 for temperature measurements.

Since modifications within the spirit and scope of the invention may readily be effected by persons skilled within the art, it is to be understood that this invention is not limited to the particular embodiment described by way of example hereinabove.

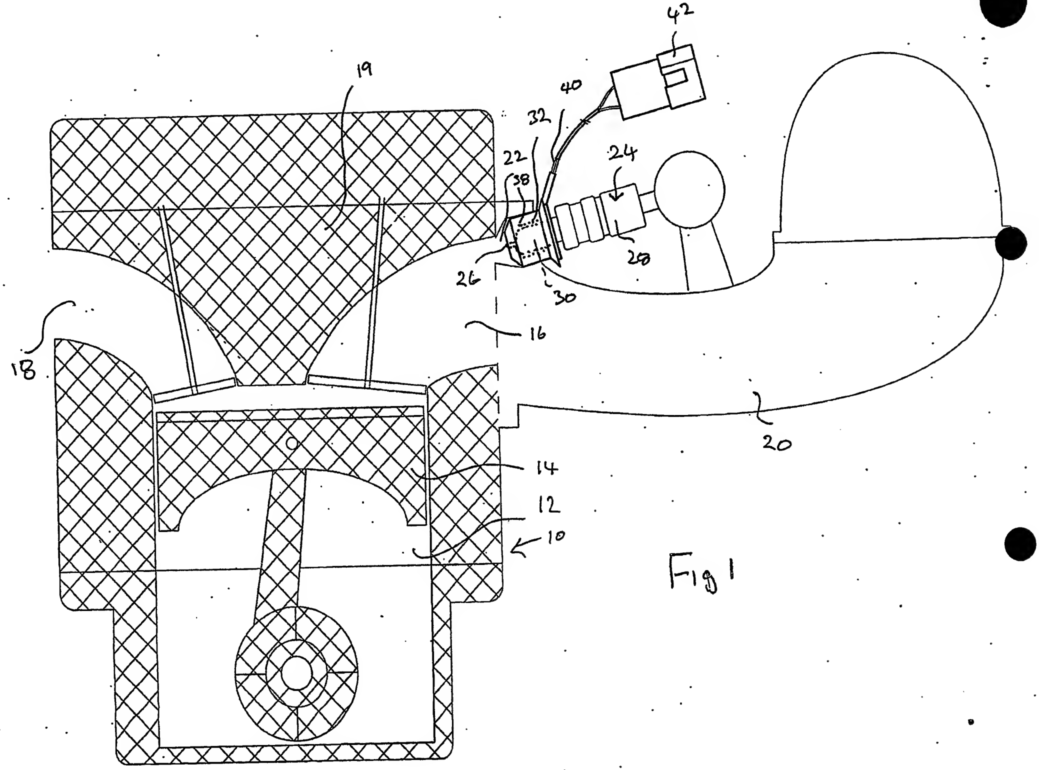

Fig 1

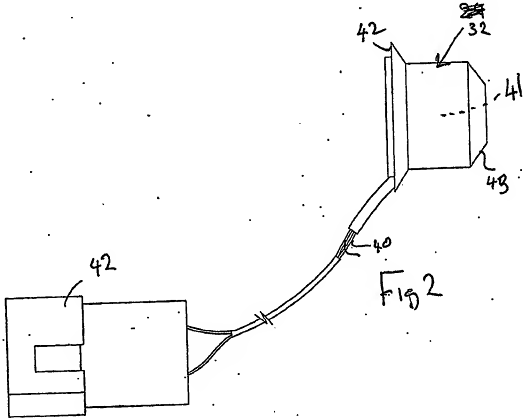

Fig 2

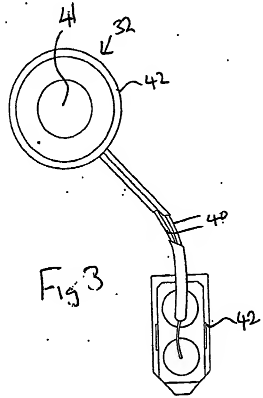

Fig 3

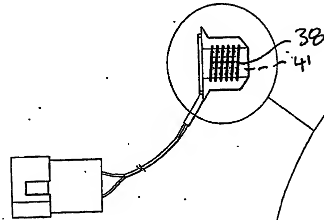

Fig 4

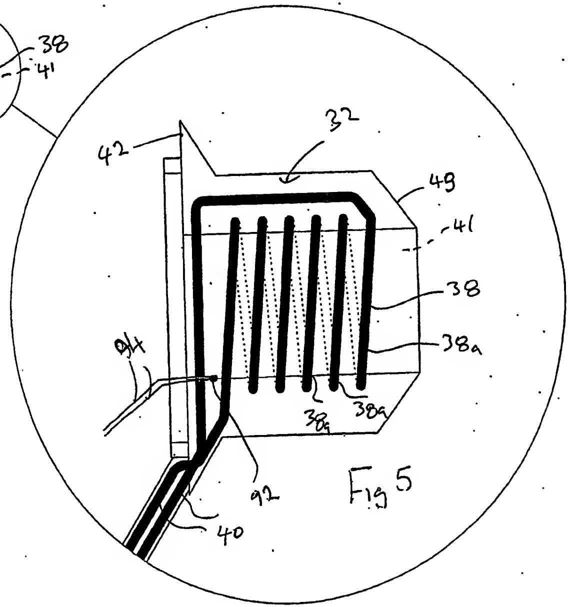

Fig 5

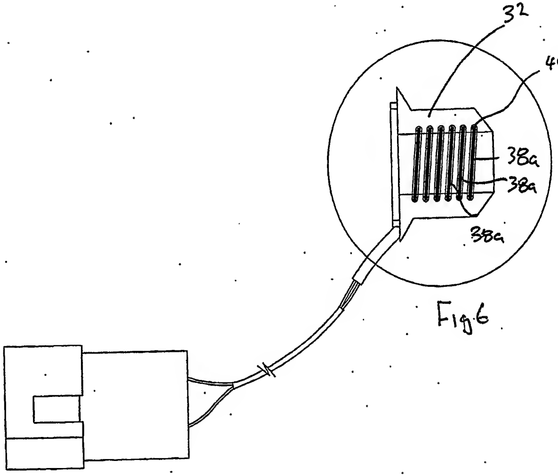

Fig 6

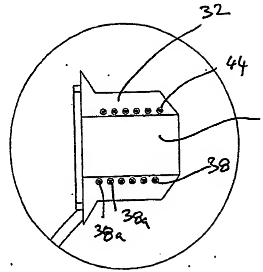

Fig 7

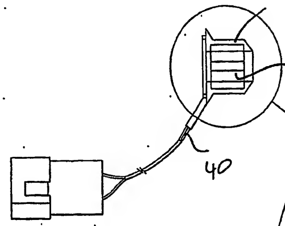

Fig 8

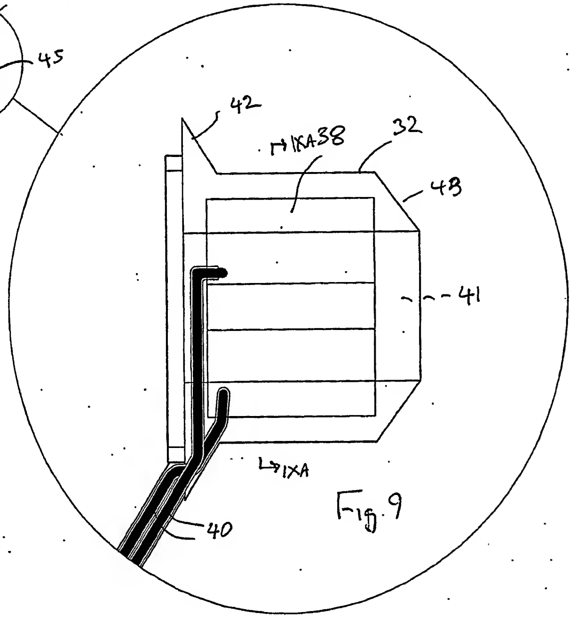

Fig 9

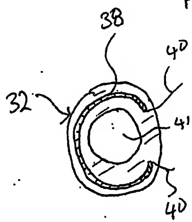

Fig 10

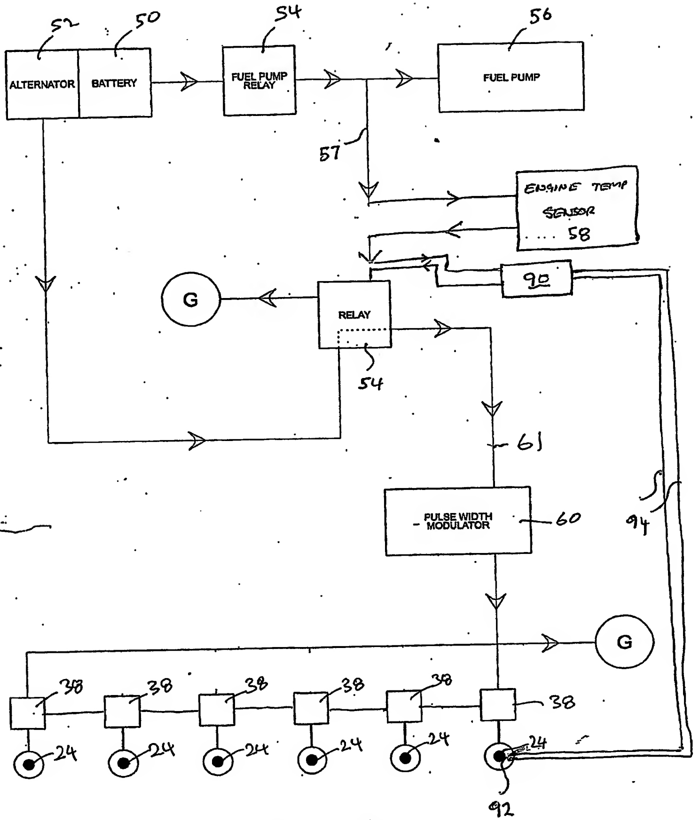
52
50
54
56
ALTERNATOR
BATTERY
FUEL PUMP RELAY
FUEL PUMP
57
ENGINE TEMP SENSOR
58
90
G
RELAY
54
61
PULSE WIDTH MODULATOR
60
94
G
38
38
38
38
38
38
24
24
24
24
24
24
92

Fig 11